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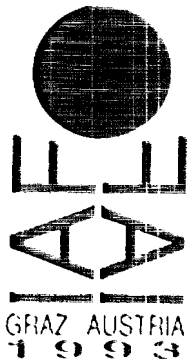

MESUR PATHFINDER: STEPS TOWARD U.S. RETURN TO THE SURFACE OF MARS

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Abstract

The Mars Environmental Survey (MESUR) project has been established to deliver and emplace a network of small landers on Mars. A key requisite for this mission is the development of a low cost, simple, robust delivery system for payloads to the Martian surface.. NASA has created tile? MESUR Pathfinder project as a precursor to the MESUR Network; its primary technology objective is to develop the delivery capability for MESUR Network, Discovery and beyond. The MESUR Pathfinder mission launches a single, integrated flight vehicle on trajectory to Mars in the November/December 1996 opportunity. At arrival in 199-/, the vehicle directly enters the atmosphere and is braked successively by an aeroshell, parachute and airbag. Once. on the surface, the vehicle rights itself by deploying petals exposing solar allays to the sky. Mockups of the flight system have been built and (I1 op tests of the airbag landing system have been made. "1'tie Pathfinder strawman scientific payload includes instruments for measuring the structure of the atmosphere during descent, a panoramic camera for determining surface morphology, and an alpha - proton-X-ray (APX) spectrometer to determine elemental composition of rocks and soil. The APX spectrometer is carried by a small rover that will bring it into contact with rocks and explore the local area. The MESUR Pathfinder project is operating within a strict development cost ceiling of $150 million. A key management objective of the project is to demonstrate NASA's ability to develop and launch a vehicle of this class to Mars within the $150 million ceiling. Pathfinder will enable affordable access to the Martian surface for 20 kg class payloads.

Introduction: Evolution of MESUR

In 19'/8, the National Academy of Science's Committee on Planetary and Lunar Exploration (COMPLEX) provided direction to the post-Viking Mars exploration program in stating:

"The primary objectives in order of scientific priority for the continued exploration of Mars are:

(1) The intensive study of local areas:

(a) To establish the chemical, mineralogical, and petrological character of different components of the surface material, representative of the known diversity of the planet;
(b) To establish the nature and chronology of the major surface forming processes;
(c) To determine the distribution, abundance, and sources and sinks of volatile materials, including an assessment of the biological potential of the martian environment, now 311(I during past epochs;

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((l) To establish the interaction of the surface material with the atmosphere and its radiation environment;

(?) To explore the structure and general circulation of the martian atmosphere;

(3) '1'() explore tilt? structure and dynamics of Mars' interior;

(4) '1'0 establish the nature of the martian magnetic field and the character of the upper atmosphere and its interaction wit h the solar wind;

(5) To establish the global chemical and physical characteristics of the martian surface." [1]

In 1983, the Solar System Exploration Committee of the NASA Advisory Council recognized that the. degree to which Mars science objectives could be accomplished depended on the establishment and operation of a network of long-lived science stations at diverse locations on the surface of Mars to perform seismic, meteorological, and geoscience observations [?]. Various concepts to establish a global Mars lander network were studied as part of the so-called "90 Day Study '([3]. In 1991, the NASA Ames Research Center developed an innovative concept for a Mars Environmental SURvey (MESUR) mission that involved the phased emplacement of a 16 lander network on Mars beginning with the first launch in the 1998/1999 opportunity and ending in 2006 after one Mars year (1.8 Earth years) of full network concurrent operations [4].

Responsibility for the Phase A study of the MESUR Network mission was assigned to the Jet Propulsion Laboratory (JPL) in November of 1991. In early 1992, JPL was directed to study the feasibility of launching a MESUR Network precursor mission under tight schedule and cost constraints to demonstrate engineering systems and technologies key to the Network. The precursor mission, designated MESUR Pathfinder, is slated for a new start as the first Discovery class mission in October 1994 with a launch in late 1996. The MESUR Network start is targeted for 1996 with the first launch targeted for no earlier than the 1998/99 opportunity.

MESUR Pathfinder

As part of the MESUR program, J]']. is studying the feasibility of landing a single vehicle on Mars in 1997 as a demonstration of the enabling systems, technologies, and management approaches for the MESUR Network mission. Because the planned Network mission will have a different, more stressful landing procedure than was used by Viking, it is important to demonstrate critical entry, descent, and safe landing functions prior to full-up implementation of the MESUR Network fabrication activity. The demonstration mission, designated MESUR Pathfinder, is the first of the Discovery class missions. Discovery missions are defined as fast schedule (3 year development cycle.), low cost ($150 million development cost cap) missions with significant, but focused, science objectives.

The primary objective of MESUR Pathfinder is to demonstrate critical functions, particularly the entry, descent, and landing function, required for the successful development and deployment of the MESUR Network stations. Technology developments to support these functions are described in a companion paper [S]. Scientific objectives and the instrument payload for Pathfinder include:

- Acquisition of atmospheric structure data along the Pathfinder entry trajectory from an entry instrument package (pressure, temperature, and vehicle acceleration),

- Characterization of surface morphology and geology at meter scale from a surface imaging camera,

* Determination of the elemental composition of rocks and/or surface materials from Alpha/Proton/X-ray spectrometer measurements.

A single MESUR Pathfinder aerocraft will be launched on a Delta class launch vehicle in December/January 1996. The Pathfinder aerocraft consists Of a cruise stage, aeroshell (heat shield and back cover), decelerator systems (parachute, solid retrorocket, and air bags), and a lander as shown in Figure 1. The aerocraft will be spin-stabilized and Earth-pointed during the cruise to Mars. Pathfinder will enter the martian atmosphere on July 4, 1997 directly from the hyperbolic transfer orbit and descend to the surface using the aeroshell, parachute, and solid retrorocket to slow the descent and an air bag system to attenuate the landing shocks as shown in Figures ? and 3. The Pathfinder landing site will be selected from available low elevation areas large enough to accommodate anticipated targeting dispersions near the sub-solar point at 15° North latitude. Landing sites near 15° North latitude provide good solar and Earth visibility conditions for the primary solar power and direct-to-Earth communications for the duration of the Pathfinder 30 day primary mission. A free-ranging, solar powered wheeled surface vehicle, developed with NASA Code C funding, will be flown on Pathfinder. The rover, as shown in Figure 4, will be deployed from the lander to conduct rover technology experiments, determine the viability of rover operations in the martian environment, and serve as deployment platform for the Alpha/Proton/X-ray spectrometer. The acquisition and return of scientific data and rover operations will commence immediately following the playback of key engineering data regarding the coalition and configuration of the lander and the characteristics of the entry. A more complete description of the rover is given in Reference 6. Figure 5 provides an artist's conception of the MESUR Pathfinder lander and deployed rover on the surface of Mars.

Acknowledgment

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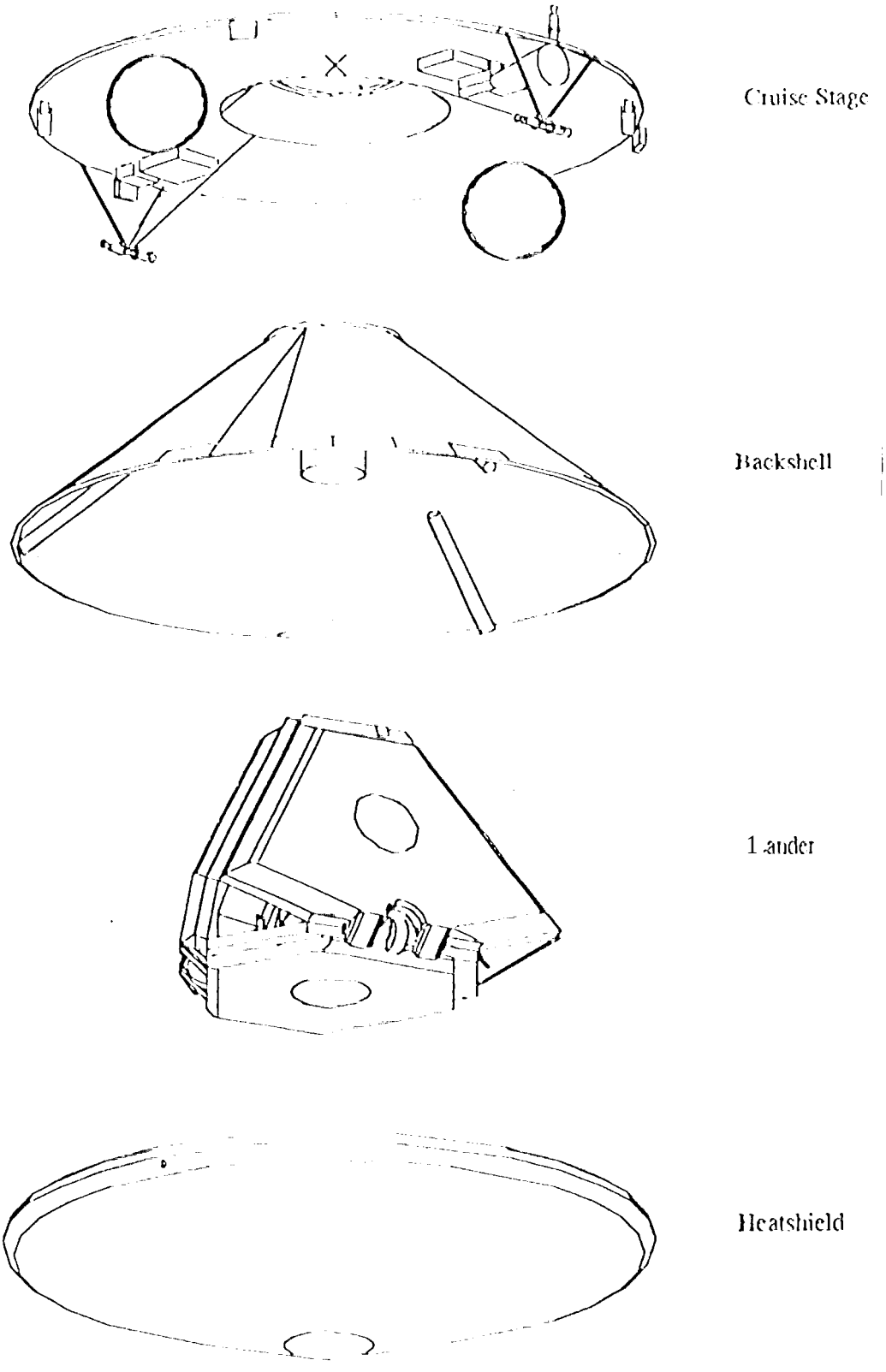

Figure 1. Exploded View of MESUR Pathfinder Flight System

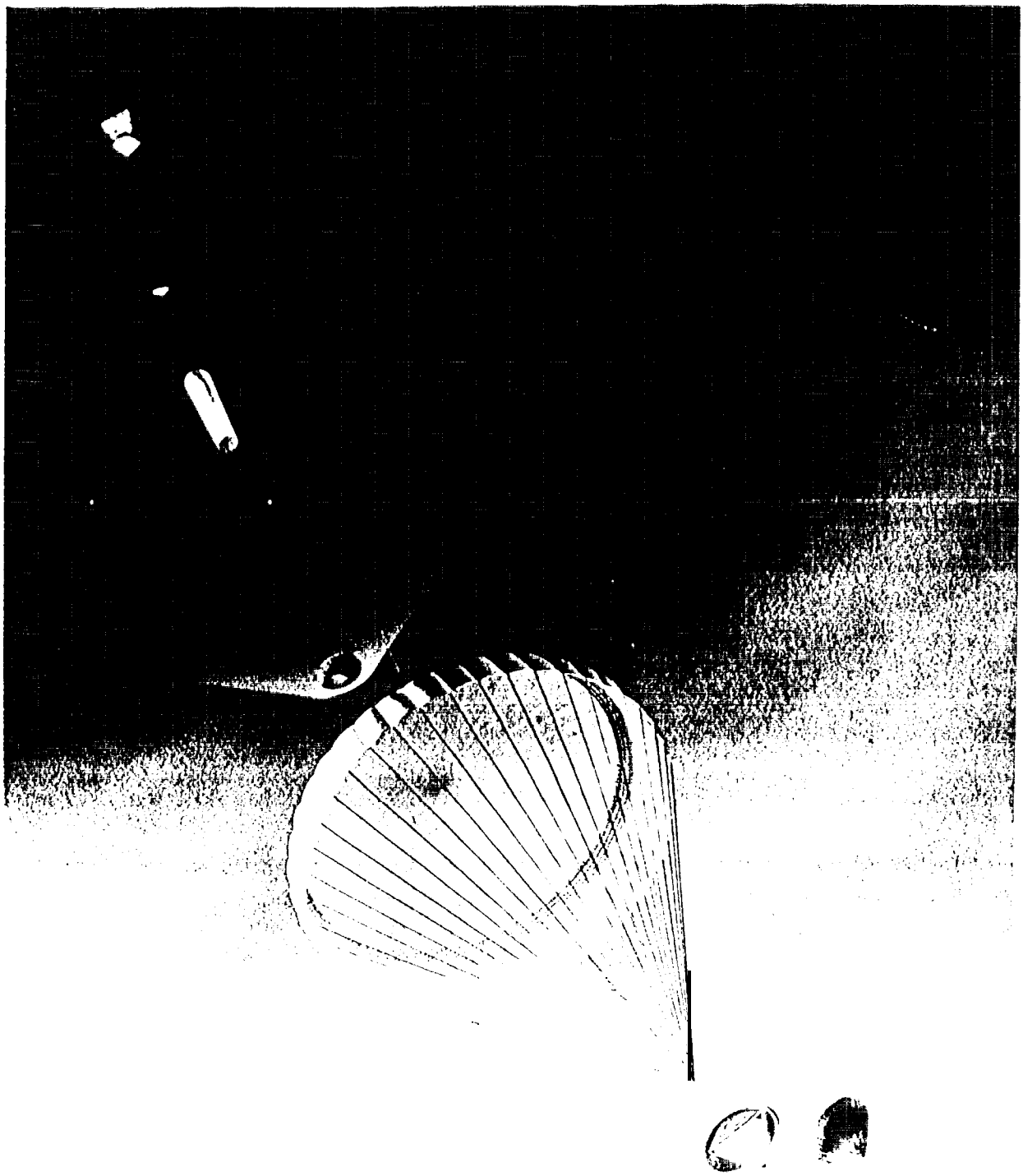

Figure 2 MESUR Pathfinder Entry Scenario

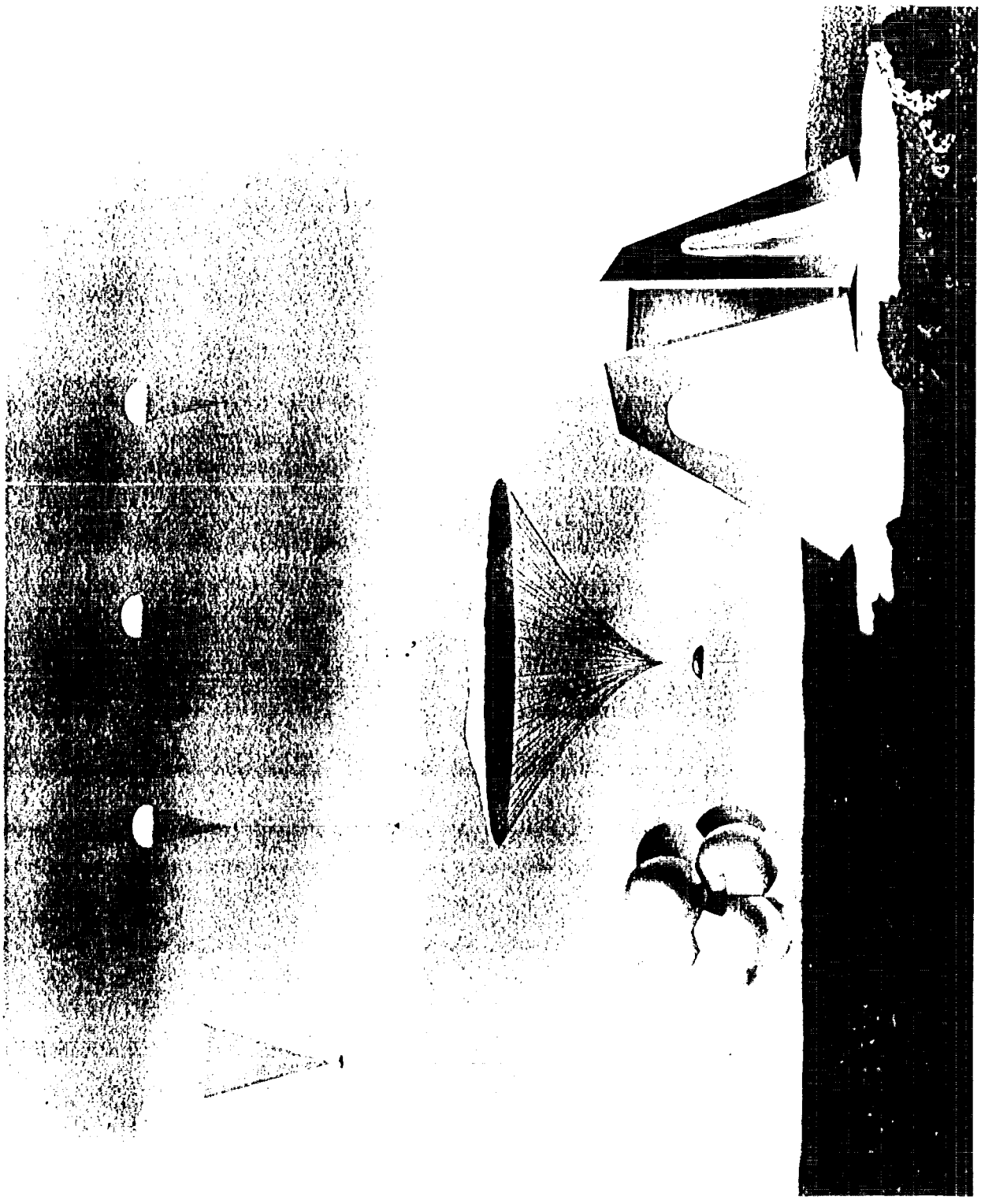

Figure 3. MESUR Pathfinder Descent and Landing Scenario

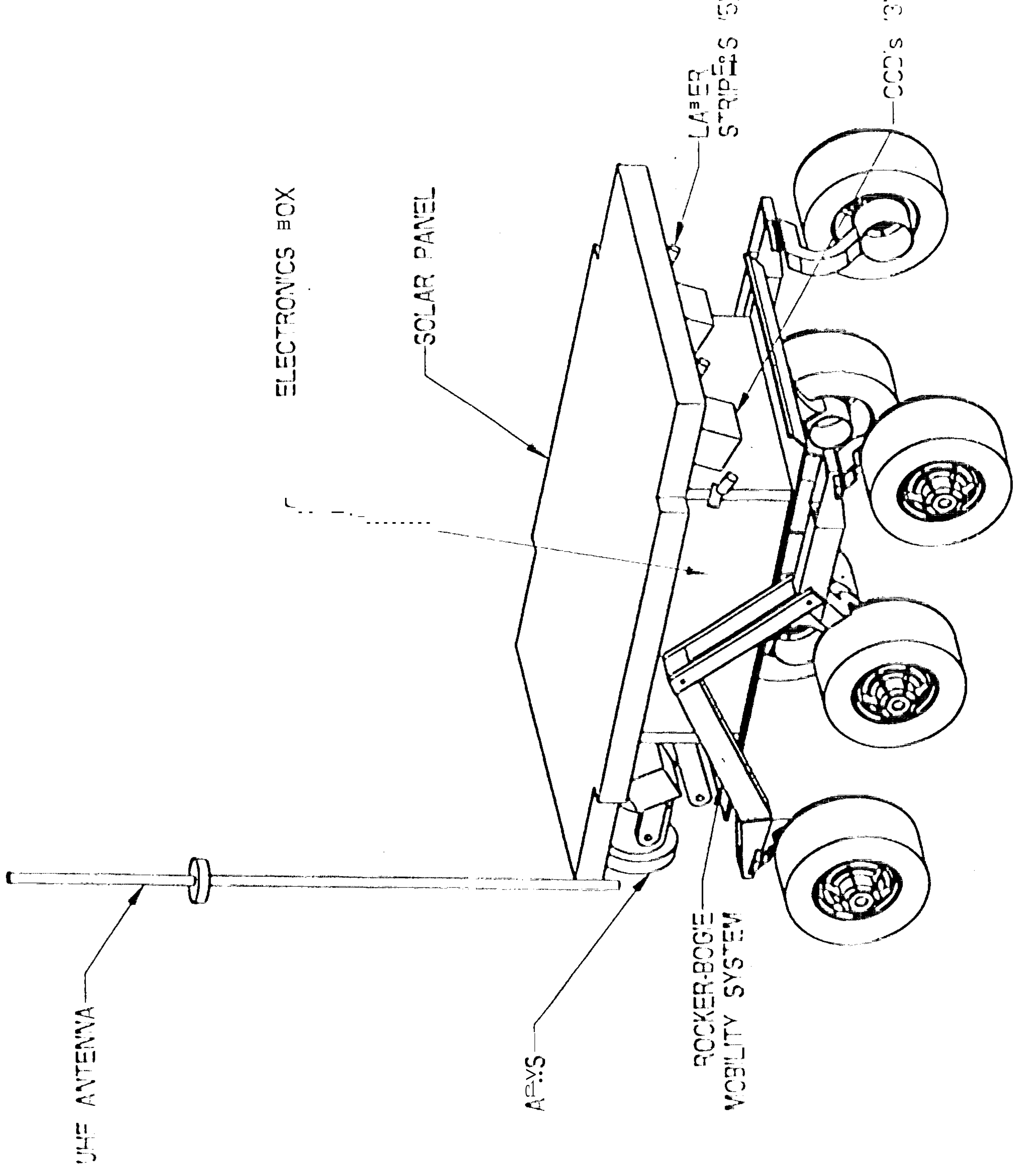

Figure 4. MESUR Pathfinder Microrover Schematic

Figure 5. MESUR Pathfinder Landed Configuration